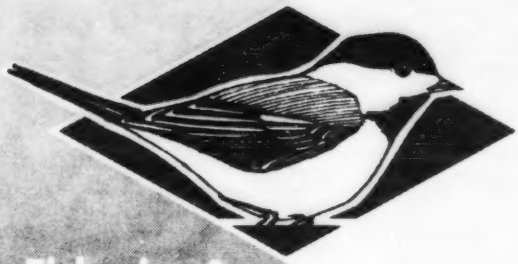
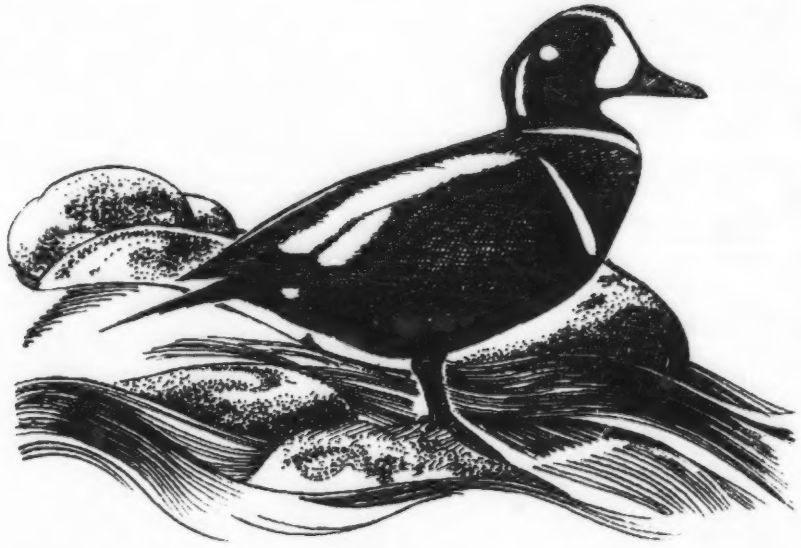


Fisheries & Wildlife Management Division
RESOURCE STATUS AND ASSESSMENT BRANCH

Harlequin Duck Research in Kananaskis Country in 2000

Cyndi M. Smith



Alberta Species at Risk Report No. 15

Alberta
SUSTAINABLE RESOURCE DEVELOPMENT

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Cyndi M. Smith

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DISCLAIMER

The views and opinions expressed are those of the author and do not necessarily represent the policies or positions of the Department or the Alberta Government.

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EXECUTIVE SUMMARY

A total of 46 harlequin ducks were captured (new bandings and recaptures) in Kananaskis Country in 2000: four males, six females and fourteen ducklings on the Kananaskis River; four males and four females on the Elbow River; three males, two females and six ducklings on the Sheep River, and; two males and one female on Cataract Creek. The population estimate of 42 (± 11 S.D.) adult harlequin ducks for the Elbow River was higher, but not significantly, than the estimates of 1997 (27 ± 4), 1998 (23 ± 4), or 1999 (28 ± 8). On the Kananaskis River the population estimate was 71 (± 19) adults, which was higher than 1999 (43 ± 10). However, this apparent increase loses significance due to high variances.

In determining survival rates, the sample sizes were smaller on the Elbow River (11 males, six females) than on the Kananaskis River (13 males, eight females). For both rivers, males had a slightly lower survival rate. The apparent lower male survival rate may reflect the pairing behaviour of harlequin ducks rather than true survival. For both sexes, the survival rates for the Elbow were lower than those of the Kananaskis River. There is no obvious explanation for the lower survival for both sexes of harlequin ducks on the Elbow River than on the Kananaskis River. Note that these estimates should be interpreted cautiously because of small sample sizes, which resulted in wide confidence intervals.

Only one of eight females (13%) observed on the Elbow River produced young ($n = 3$) in 2000. This was lower than in 1997 (23%), 1998 (28%), or 1999 (20%). On the Kananaskis River four of 11 females (36%) produced ducklings ($n = 14$) in 2000. In 1999, five of 12 females (42%) produced ducklings ($n = 19$), and in 1998 three of eight females (37%) produced 10 ducklings. The estimated net reproductive rate for the Elbow River has declined from 6.24 to 1.18 between 1996 and 2000, while for the Kananaskis River it has remained similar at 3.90, 4.93 and 3.96 for 1998-2000 respectively. It is uncertain what effect increasing recreational boating use of the Elbow River is having on harlequin duck productivity. If the reproductive output continues to be less than 2.0 then the population could eventually decline.

Two young females that had been banded in Kananaskis Country were sighted at great distances from their natal streams. One female banded as a duckling at Smith-Dorrien Creek in August 1998 was observed with a male on Upper McDonald Creek in Glacier National Park, Montana. Another female was observed on the Athabasca River near Jasper, Alberta. She had been banded as a duckling in August 1998 on the Kananaskis River. These are the first recorded observations of young females dispersing from their natal area during the breeding season.

Monitoring harlequin duck populations should continue in Kananaskis Country. This is particularly true for the Elbow River to determine if the decline in reproductive output is a true decline or a dip in long-term variability. The reach of the Kananaskis River between the Kananaskis Golf Course and Barrier Lake continues to support a large number of harlequin ducks, and has high productivity. This reach may be critical to maintaining the harlequin duck population in Kananaskis Country and no further development or activities should be allowed along the river. Cataract Creek has only been partially surveyed, but may be an important breeding stream in the southern part of the study area.

1.0 INTRODUCTION

Harlequin ducks (*Histrionicus histrionicus*) are small sea ducks (tribe Mergini) that spend eight to ten months of the year at coastal areas and migrate inland during the summer to nest along mountain streams (the only duck in North America to do so). In Alberta these ducks nest in relatively low densities throughout the Rocky Mountains and the foothills of the Eastern Slopes. In 1996 harlequin ducks were added to the Yellow "A" list of endangered and threatened species in Alberta (Anon. 1996): "sensitive species that are not currently believed to be at risk, but may require special management to address concerns related to naturally low populations, limited provincial distributions, or demographic/life history features that make them vulnerable to *human-related* [emphasis theirs] changes to the environment."

Since 1995, research in Kananaskis Country has contributed significantly to an understanding of the habitat and conservation needs of harlequin ducks in the province. That year Kananaskis Country-Parks initiated surveys on the Elbow, Sheep and Highwood Rivers. Since 1996 researchers have utilized capture-mark-recapture/resighting (CMR) methodology on these rivers as well as on the Kananaskis River (Figure 1). From 1997 to 1999 radio telemetry techniques were used to study nesting and productivity of harlequin ducks on the Elbow and Kananaskis rivers.

2.0 OBJECTIVES

The specific objectives for the 2000 field season were:

a) To describe the abundance, population structure, survival rates, trends and productivity of harlequin ducks on the Elbow and Kananaskis rivers.
b) Continue baseline work in order to monitor abundance and population structure on the Sheep and Highwood rivers, and Cataract Creek.
c) Make recommendations to Bow Region managers and biologists regarding harlequin duck conservation.

3.0 METHODS

3.1 Banding

In order to describe the demography and site fidelity of harlequin ducks in Kananaskis Country (KC) it has been necessary to be able to identify individual birds. An 18-m mist net was set across the river at a location where unbanded birds were observed and the birds were actively flushed towards it. The ducks were marked with standard numbered aluminum bands on the right leg and an auxiliary red plastic numeric-numeric or alpha-alpha (white letters) band on the left leg. Sex of adults was determined by plumage characteristics. The age of adult males was determined by plumage, and all males in full definitive alternate plumage were classified as after second year (ASY)(Smith et al. 1999). Age of adult females was determined by the depth of the Bursa of Fabricius (Mather and Esler 1999), and was classified as third year (TY) or after third year (ATY). Ducklings' age were determined by plumage characteristics and their sex by the presence or absence of a penis (Kortright 1943).

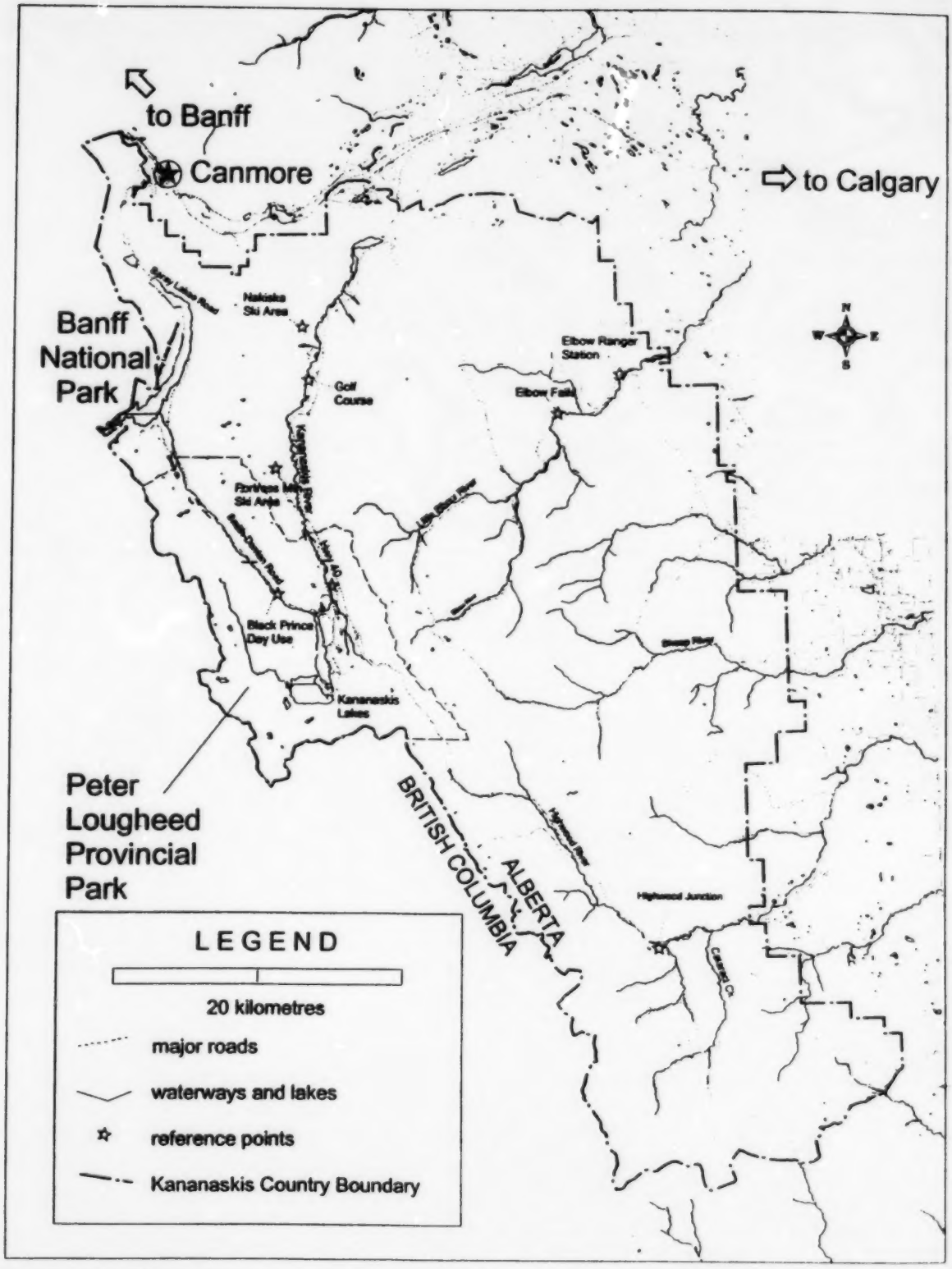

Figure 1. Harlequin Duck research project study area, Kananaskis Country, 1996-2000.

Measurements recorded were: length of exposed culmen and tarsus bone (Dzubin and Cooch 1992) to the nearest 0.1 mm, wing notch length (Henny et al. 1981) to the nearest mm, and mass to the nearest 5 g (using a Pesola spring scale). Broods were aged by plumage class using the system developed by Gollop and Marshall (1954) and adapted by Kuchel (1977) for harlequin ducks. Class I young are downy, class II partly feathered, and class III fully feathered. The banding was undertaken under the following permits and licences: federal banding permit #10701, provincial research permit #2665GP, and provincial collection licence #1907.

3.2 Roadside/Hiking Surveys

Roadside surveys for censusing harlequin ducks and re-sighting marked birds were conducted along the Elbow River and the Kananaskis River. A spotting scope was used to ascertain banded status. Data was entered on a standardized form, and included location (descriptive and UTM), number, sex, whether paired or single, band codes where possible, and activity. Data from roadside surveys was used to estimate the sex ratio and the number of birds in the population, as well as survival rate.

Estimating population size

A Capture-Mark-Recapture/Resighting (CMR) methodology was used to calculate the population estimate (N). The basic assumptions of the CMR methodology are (Skalski and Robson 1992):

1. There are equal and independent capture (resighting) probabilities for all animals within a sampling period.
2. Marking does not affect catchability or resighting (implied by first assumption).
3. Animals do not lose their marks.
4. All marked animals captured (resighted) in subsequent periods are reported.
5. Animals are randomly sampled either in all periods, or systematically after random mixing of marked and unmarked animals.
6. The population is closed, or if mortality only (no recruitment) is occurring, then N estimates population abundance at time of samples subsequent to initial marking.

Additionally, a number of assumptions specific to this project were made:

1. Birds marked in other studies (e.g. Strait of Georgia, Macleod River) were included as part of the marked population when they were first sighted on the breeding stream.
2. Birds banded as juveniles were not included as part of the marked population until they were re-sighted on the breeding stream, whereupon they were treated as newly banded birds.
3. The number of marked adults at the start of 1999 was determined from the birds marked or re-sighted in previous years, taking into account annual mortality for adult males of 0.14 and for adult females of 0.22 (Smith 1998).
4. Only surveys to June 16 were included, as after that date females were less likely to be observed than males, which would violate assumption 1 above.
5. The population was treated as closed, but this may not be true.

The following formulas were used in this project:

1. Mark-resighting formula, [revised and adjusted for bias, based on Chapman (1951)]:

$$N \text{ (population estimate)} = \frac{(N_1 + 1)(N_2 + 1)}{(M_2 + 1)} - 1$$

where N_1 = initial number of marked birds
N_2 = number of birds in subsequent sample whether banded or not
M_2 = number of marked birds in the subsequent sample

2. Variance $(S^2) = \frac{(N_1 + 1)(N_2 + 1)(N_1 - M_2)(N_2 - M_2)}{(M_2 + 1)^2 (M_2 + 2)}$

3. Standard Deviation = $\sqrt{S^2}$

4. Population estimate presented as: $N \pm$ S.D.
   Or $N \pm$ S.E. (S.E. = S.D. + $\sqrt{N}$)
   Or with 95% C.I. (S.D. x 1.96)

Estimating survival rates

Estimation of survival rates may be confounded by emigration and immigration, which are very difficult to measure. Estimation is even more difficult for males due to the fact that some males that have only been sighted once may be alive but breeding in a different area. If a male's original mate dies, he will attempt to re-pair (Smith et al. 2000) and would follow his new mate to her natal stream. With the strong natal and breeding philopatry of female harlequin ducks however, that bias is much smaller. The annual survival of harlequin ducks may be analyzed using marked individuals. Survival rate is a function of both the probability of the bird surviving, and the probability that the bird is resighted.

The software program utilized for estimating survival rates was MARK (White and Burnham 1999). The latest version of the software may be downloaded from <http://www.cnr.colostate.edu/~gwhite/mark/mark.htm>. The presence or absence of cohorts of marked adults (both those banded here and elsewhere) was used to estimate local survival rates. Since the analysis requires a minimum of three years of data, results from 1996-1998 for the Elbow River and 1998-2000 for the Kananaskis River were utilized.

3.2.1 Elbow River surveys

As in previous years, the Elbow River roadside/hiking survey was conducted between Elbow River Campground and Paddy's Flat Campground (see App. A in Smith [1999] for details). The total river distance was about 25 km, and about 10 km (40%) of the river was covered during the survey (not contiguous stretches).

3.2.2 Kananaskis River surveys

The total distance of the Kananaskis River roadside/hiking survey was approximately 12 km, 60% of which was covered during the survey, between Barrier Lake and the Kananaskis Country Golf Course (see App. B in Smith [1999] for details).

3.3 Brood Surveys

Surveys for females with broods were conducted by hiking along the streams, moving upstream. Ducks, if disturbed, often float downstream and therefore would not be re-counted. Surveyors walked carefully and quietly, using binoculars to scan the stream, particularly eddies behind rocks and shoreline loafing sites.

Estimating productivity

Waterfowl productivity estimates are based on pair and brood counts which furnishes an index provided three assumptions are met: (1) all breeding pairs and their broods are counted, (2) pairs that are counted do not produce broods elsewhere and (3) broods produced elsewhere do not move into the area (Cowardin and Blohm 1992). For pair counts females were utilized, as they are the limiting sex and it is not always easy to determine pair status. Productivity estimates were based on the number of ducklings and females observed on the Elbow and Kananaskis rivers (Nichols 1991).

In the spring, observations from roadside/hiking surveys were used to determine the count of females on each river. During the third and fourth weeks of August, brood surveys determined the number of surviving females and class 3 ducklings (fully feathered but flightless; Gollop and Marshall 1954). This time period was chosen since the water levels were lower resulting in increased visibility of birds, as well as the females and broods were less likely to have migrated by then. These counts provide a relative index rather than an absolute number on a yearly basis, due to the facts that the spring count of females does not account for adult mortality during the summer, or for emigration of non-breeding or failed breeding females back to the wintering area. Additionally, since ducklings are susceptible to predation until migration, the duckling count is likely estimated high.

High natural variation in productivity, common with all of the sea ducks (Goudie et al. 1994, Krementz et al. 1997), makes it difficult to apply significance to trends. However it is useful to examine the net reproductive rate (R_0) — the average number of offspring produced by an average female over an average lifespan — as a measure of the rate of change of a population's size. If R_0 is > 2.0, there is a net surplus of offspring produced during each generation (replacing both the female and her mate). If $R_0 < 2.0$ then the population is not replacing itself and will decline (Gotelli 1995). The R_0 is calculated by multiplying the estimated adult survival rate (0.78) by the number of ducklings per female and summing these products across the reproductive life span. This study calculated the reproductive life span as 4 years ($1.0 + [-ln0.78] = 4$ years; as per Anderson 1975).

3.4 Random Observations

Random observations of harlequin ducks, outside of survey times and places, were also recorded. Observations from throughout KC were collected from Alberta Fish and Wildlife (formerly Natural Resources Service) staff and the general public.

4.0 RESULTS

All sightings from surveys and random observations in KC in 2000 are recorded in Appendix A. Appendix B is a history of the banding and resighting of each marked bird in Kananaskis Country since 1995.

4.1 Tarsus Banding

In the spring a total of 21 ducks were captured: 16 were new bandings and five had been previously banded (Table 1). Of the 21, four males and two females were captured on the Kananaskis River, four males and four females on the Elbow River, three males and one female on the Sheep River, and two males and one female on Cataract Creek. An additional 25 harlequin ducks were captured in August: two non-breeding females and two females with 14 young (one female and two young escaped) on the Kananaskis River; one female with six young (one duckling escaped) on the Sheep River.

4.2 Roadside/Hiking Surveys

4.2.1 Elbow River surveys

Five roadside/hiking surveys were completed on the Elbow River (Table 2). Figures 2 and 3 show the spatial distribution of birds during the surveys. The highest pair count on the 10-km survey was six pairs on May 26, for a density of 0.60 pairs/km. An average of 54.5% of the birds observed were banded and the average sex ratio was 1.6 M:F. A population estimate of 42 ± 11.1 (S.D.) was generated from the survey data (Table 3). There was no difference in estimates among years 1996-2000 ($F_{4,18} = 1.83$, $P = 0.17$), so all five years were pooled. The median annual population estimate for the five years was 27 adults (Table 4). Due to high variances, there is considerable overlap in 95% C.I. among years (Fig. 4), and the apparent increase loses significance.

Table 1. Band codes and numbers, and morphometrics of harlequin ducks banded or recaptured in Kananaskis Country in 2000.

USFWS band #	code [a]	age/ sex	wing (mm)	culmen (mm)	tarsus (mm)	weight (g)	Capture Date	location	comments
New									
190507159	LI	ASY-M	202	27.6	35.2	615	9-May	Kananaskis R.	
190507160	LJ	ASY-M	210	26.8	37.3	600	9-May	Kananaskis R.	
190507161	LZ	AHY-F	195	26.3	38.5	530	11-May	Elbow R.	mate of LU
190507162	LU	ASY-M	210	27.9	38.4	600	11-May	Elbow R.	mate of LZ
190507163	LR	ASY-M	202	26.4	35.6	575	11-May	Elbow R.	mate of 37
190507164	US	ATY-F	195	24.1	32.5	540	11-May	Elbow R.	mate of UP
190507165	UP	ASY-M	203	27.2	36.4	620	11-May	Elbow R.	mate of US
190507166	UI	TY-F	197	26.2	37.0	525	12-May	Kananaskis R.	mate of UV
190507167	UV	ASY-M	203	26.9	35.9	550	12-May	Kananaskis R.	mate of UI
190507168	UJ	ASY-M	210	27.1	38.6	610	24-May	Sheep R.	
190507169	UG	ASY-M	210	28.9	36.8	585	24-May	Sheep R.	
190507170	UO	SY-F	189	24.4	34.0	453	24-May	Sheep R.	
190507171	UA	ASY-M	212	27.6	36.9	615	24-May	Sheep R.	
190507172	UK	ASY-M	205	26.5	38.7	650	26-May	Cataract Ck.	
190507173	UU	ASY-M	205	27.4	37.0	545	26-May	Cataract Ck.	mate UF
190507174	UF	TY-F	194	26.2	37.1	640	26-May	Cataract Ck.	mate UU
190507701	UN	HY-M	182	23.2	34.9	500	22-Aug	Kananaskis R.	prog. of XR
190507702	UX	HY-F	181	23.2	34.1	505	22-Aug	Kananaskis R.	prog. of XR
190507703	UY	HY-M	187	23.8	37.0	570	22-Aug	Kananaskis R.	prog. of XR
190507704	UL	HY-M	194	24.8	35.2	575	22-Aug	Kananaskis R.	prog. of XR
190507705	UB	HY-M	189	24.0	38.2	595	22-Aug	Kananaskis R.	prog. of XR
190507706	UR	HY-M	163	23.0	36.4	435	23-Aug	Kananaskis R.	prog. of UZ
190507707	UC	HY-F	163	22.6	36.1	410	23-Aug	Kananaskis R.	prog. of UZ
190507708	UH	HY-F	162	22.4	34.3	395	23-Aug	Kananaskis R.	prog. of UZ
190507709	UE	HY-M	163	22.8	36.8	455	23-Aug	Kananaskis R.	prog. of UZ
190507710	UZ	TY-F	197	25.0	34.9	460	23-Aug	Kananaskis R.	with 4 HY
190507711	ZU	SY-F	195	26.3	35.2	540	23-Aug	Kananaskis R.	
190507712	ZS	HY-F	184	23.8	34.4	485	28-Aug	Kananaskis R.	hen not captured
190507713	ZJ	HY-M	190	25.6	36.2	560	28-Aug	Kananaskis R.	hen not captured
190507714	ZT	HY-F	182	24.1	34.2	460	28-Aug	Kananaskis R.	hen not captured
190507715	ZH	HY-M	197	25.1	37.8	605	28-Aug	Kananaskis R.	hen not captured
190507716	ZZ	HY-F	186	23.2	34.0	460	28-Aug	Kananaskis R.	hen not captured
190507717	ZG	HY-M	197	27.1	37.8	570	30-Aug	Sheep R.	prog. of ZN
190507718	ZN	ATY-F	198	27.1	36.8	560	30-Aug	Sheep R.	7 HY; one missed
190507719	ZX	HY-M	199	26.9	38.1	585	30-Aug	Sheep R.	prog. of ZN
190507720	ZE	HY-F	184	24.3	35.2	460	30-Aug	Sheep R.	prog. of ZN
190507721	ZF	HY-M	189	25.9	36.3	490	30-Aug	Sheep R.	prog. of ZN
190507722	ZY	HY-F	192	25.9	35.4	520	30-Aug	Sheep R.	prog. of ZN
190507723	ZK	HY-M	190	26.2	37.2	570	30-Aug	Sheep R.	prog. of ZN

Table 1, continued

Table 1, continued

USFWS band #	code [a]	age/ sex	wing (mm)	culmen (mm)	tarsus (mm)	weight (g)	Capture Date	location	comments
Recap									
92522257	ZV(32)	ATY-F	195	24.9	36.1	560	23-Aug	Kananaskis R.	replaces 32
92522269	37	ATY-F	198	25.4	33.6	590	11-May	Elbow R.	mate LR
92523108	EE	ASY-M	209	26.7	35.5	615	11-May	Elbow R.	
92523503	ST	ATY-F	194	25.2	33.8	565	10-May	Elbow R.	
92523513	XR	ATY-F	196	24.4	35.3	600	22-Aug	Kananaskis R.	with 5 HY
93558237	NS-aq	ASY-M	198	26.5	37.9	580	9-May	Kananaskis R.	
190517831	VJ	TY-F	205	24.5	44.2	640	9-May	Kananaskis R.	

[a] red band on the left leg except where noted colours: aq – aqua r - right leg prog. – progeny
HY – hatch year (duckling) ASY – after second year (adult) ATY – after third year (adult)
TY – third year (adult) SY – second year (adult: non-breeding) AHY – after hatch year (adult)

Table 2. Results of roadside surveys for harlequin ducks on the Elbow River, 2000.

Date	Total	M	F	# Pairs	# banded of	% banded	M:F
6-May	0	0	0	0	0	0	0.00
12-May	11	6	5	5	9 of 11	82	1.20
20-May	8	4	4	4	4 of 8	50	1.00
26-May	13	7	6	6	6 of 13	46	1.17
11-Jun	4	3	1	1	2 of 4	50	3.00

[a] # known = number known if banded or not

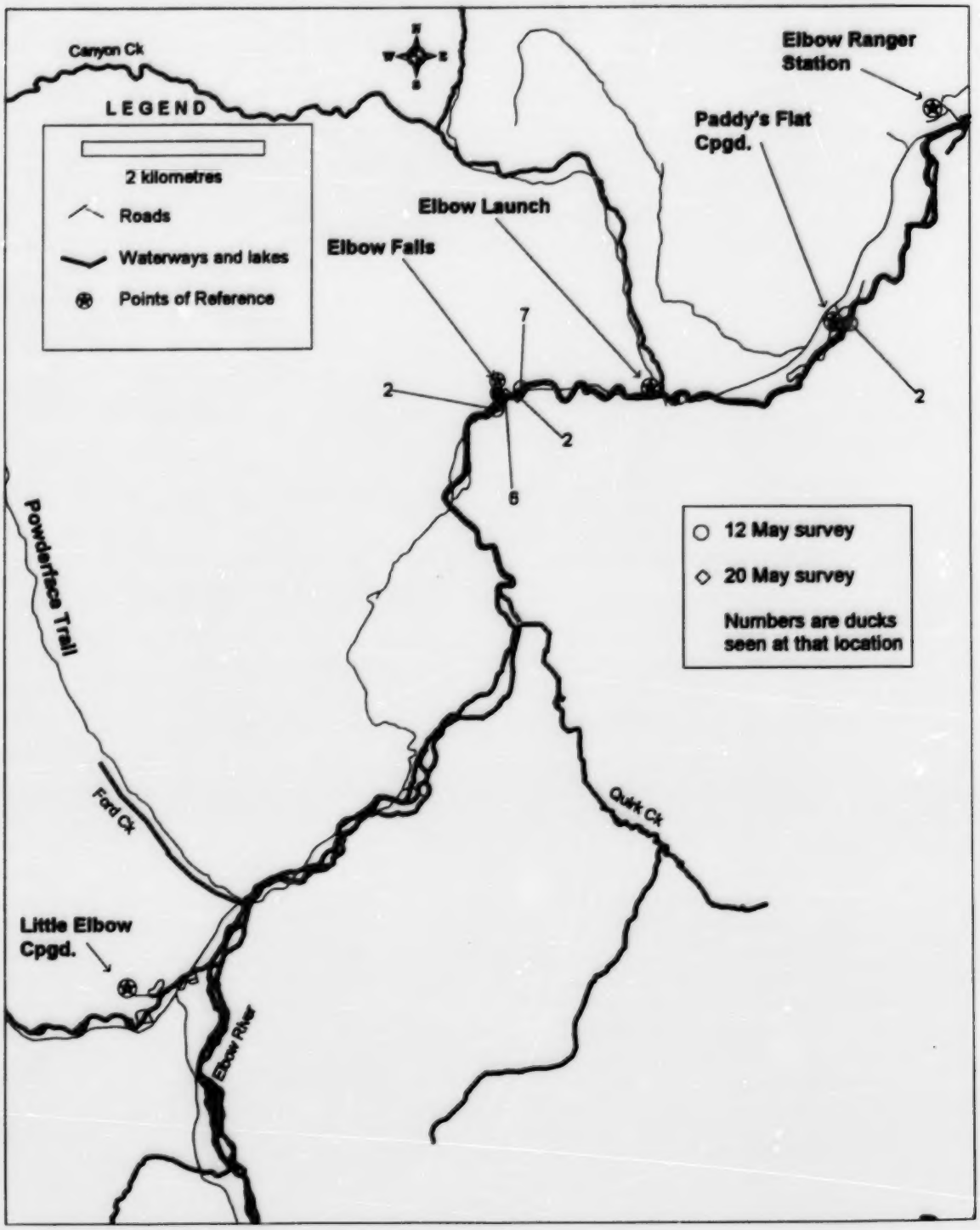

Figure 2. Locations of Harlequin Ducks observed on the Elbow River during roadside/hiking surveys on 12 May (n = 11) and 20 May (n = 8), 2000

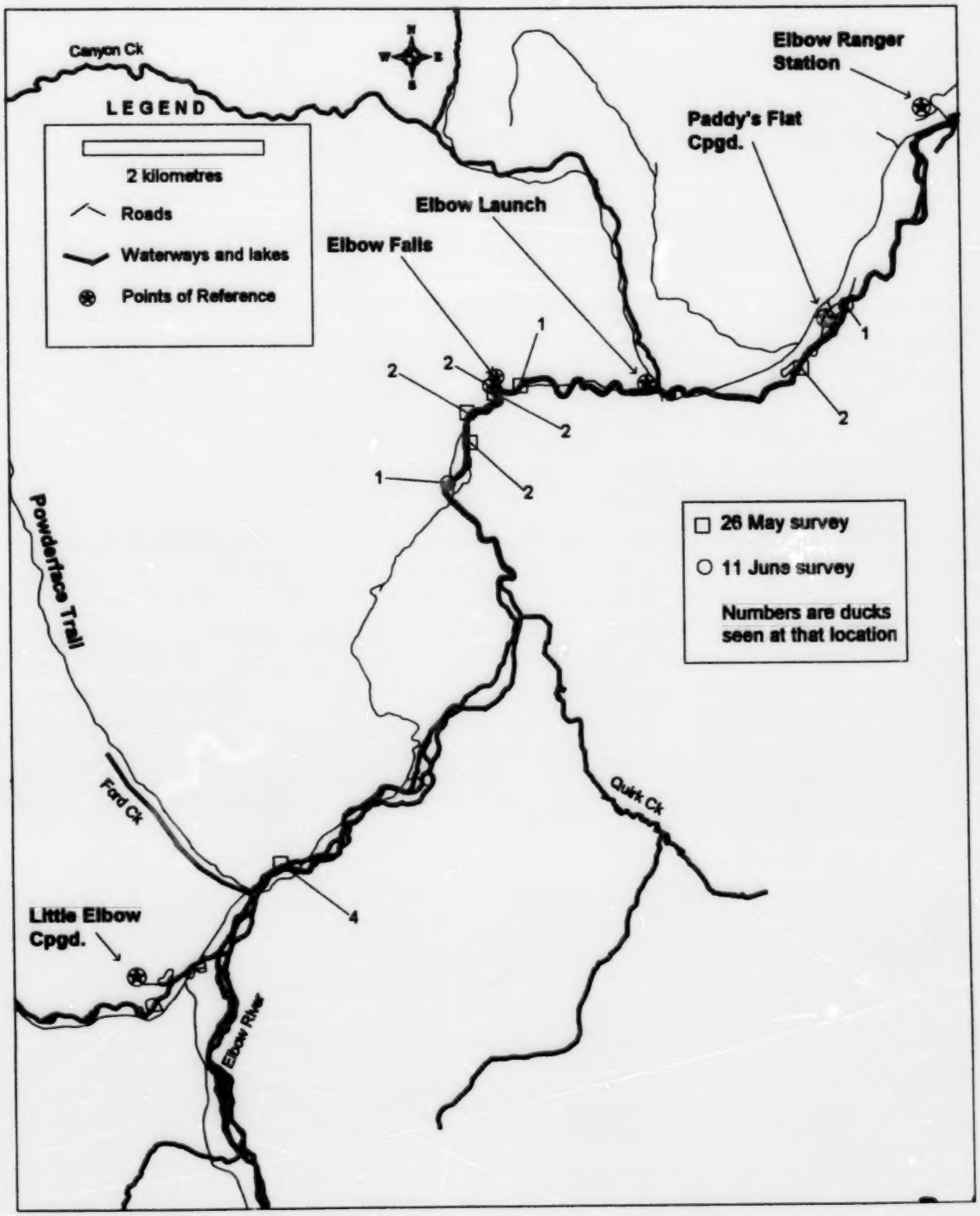

Figure 3. Locations of Harlequin Ducks observed on the Elbow River during roadside/hiking surveys on 26 May (n = 13) and 11 June (n = 4), 2000.

Table 3. Population estimates for harlequin duck as calculated from roadside surveys on the Elbow River. 2000.

Date	initial # of marked birds (N_1)	# known if banded (N_2)	# banded (M_2)	Pop. est. (N)	Variance (S^2)	S.D.	S.E.	95% C.I.
6-May	17	0	0	18.0	0.0	0.0	0.0	0.0
12-May	25	11	9	30.0	9.1	3.0	0.5	5.9
20-May	25	8	4	46.0	131.0	11.4	1.7	22.3
26-May	25	13	6	51.0	123.5	11.1	1.6	21.8
11-Jun	25	4	2	42.0	166.1	12.9	2.0	25.3
median				42.0	123.5	11.1	1.6	21.8

Table 4. Population estimates for adult harlequin ducks as calculated from roadside surveys (*n*) on the Elbow River, 1996-2000.

Year	n=	Pop. Est. (N)	Variance	S.D.	S.E.	95% C.I.
1996	4	11.5	14.0	3.8	1.1	7.4
1997	5	27.0	15.1	3.9	0.8	7.6
1998	5	23.2	17.8	4.2	1.0	8.2
1999	4	27.5	75.3	7.6	1.4	14.8
2000	5	42.0	123.5	11.1	1.6	21.8
Median		27.0	17.8	4.2	1.1	8.2

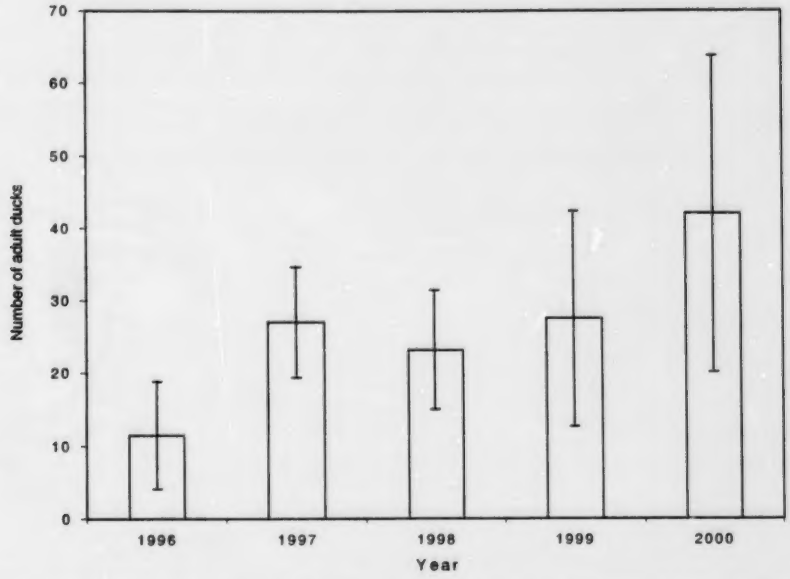

Figure 4. Population estimates for adult harlequin ducks on the Elbow River, 1996-2000.

4.2.2 Kananaskis River surveys

Five roadside/hiking surveys were completed on the Kananaskis River (Table 5). Figures 5 and 6 show the spatial distribution of birds during the surveys in May and June, respectively. The highest pair count was five pairs in the 12 km of the survey route, on May 28, for a density of 0.42 pairs/km. An average of 51.3% of birds observed were banded and the average sex ratio was 1.9 M:F. A population estimate of 71 ± 19.3 (S.D.) was generated from the survey data (Table 6). This was the highest estimate since 1998 (Table 7), and is higher than the population estimate from 1999 (t = -3.87, P = 0.003). Due to high variances, there is considerable overlap in 95% C.I. among years (Fig. 7), and the apparent increase loses significance.

Table 5. Results of roadside surveys for harlequin ducks on the Kananaskis River, 2000.

Date	Total	M	F	# Pairs	# banded of	% banded	M:F
5-May	5	5	0	0	0 of 2	0	0
13-May	6	4	2	2	5 of 6	83	2
19-May	12	8	4	3	3 of 9	33	2
28-May	11	6	5	5	5 of 11	45	1.2
10-Jun	13	9	4	3	4 of 9	44	2.3

[a] # known = number known if banded or not

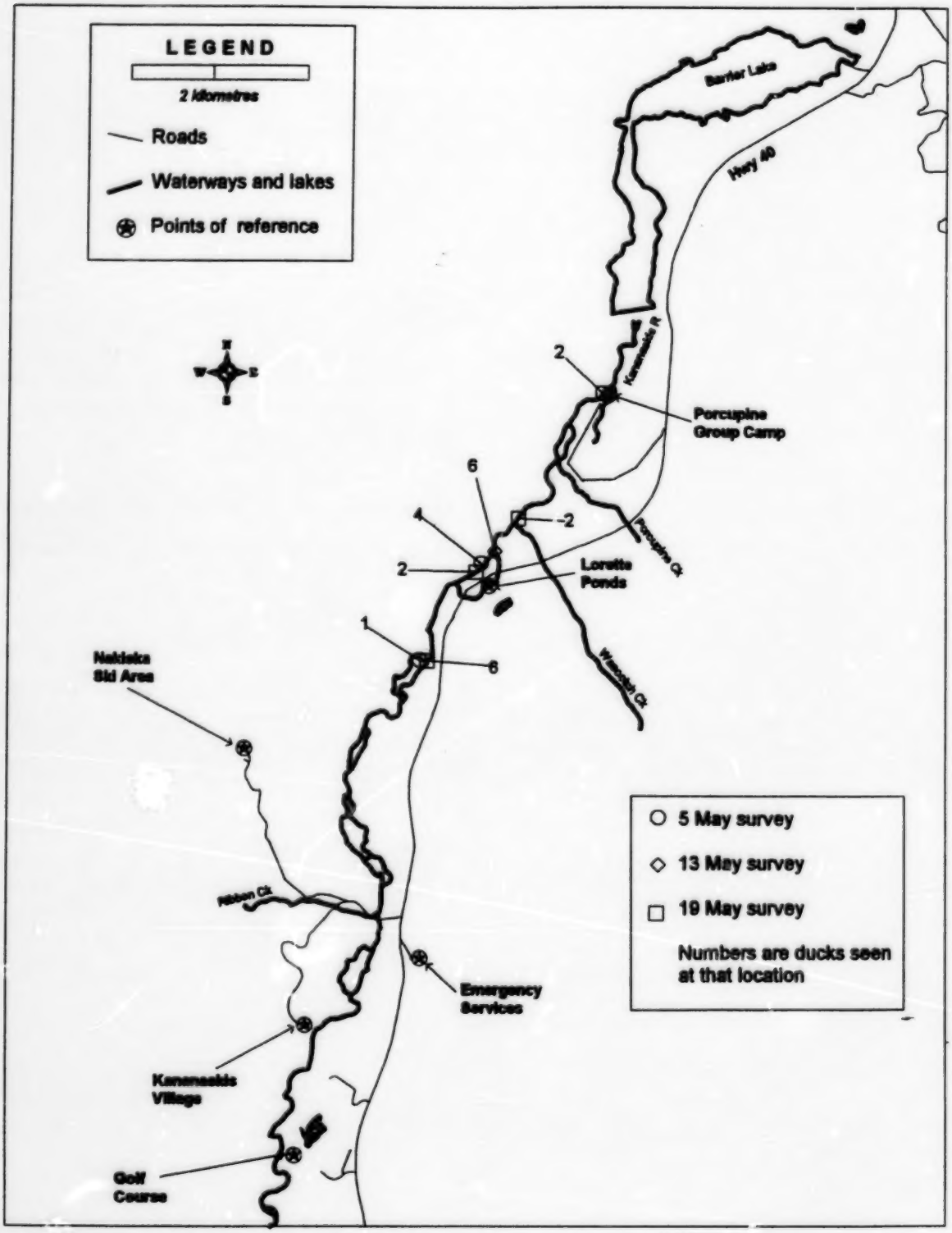

Figure 5. Locations of Harlequin Ducks observed on the Kananaskis River during roadside/hiking surveys on 5 May (n = 5), 13 May (n = 6), and 19 May (n = 12), 2000.

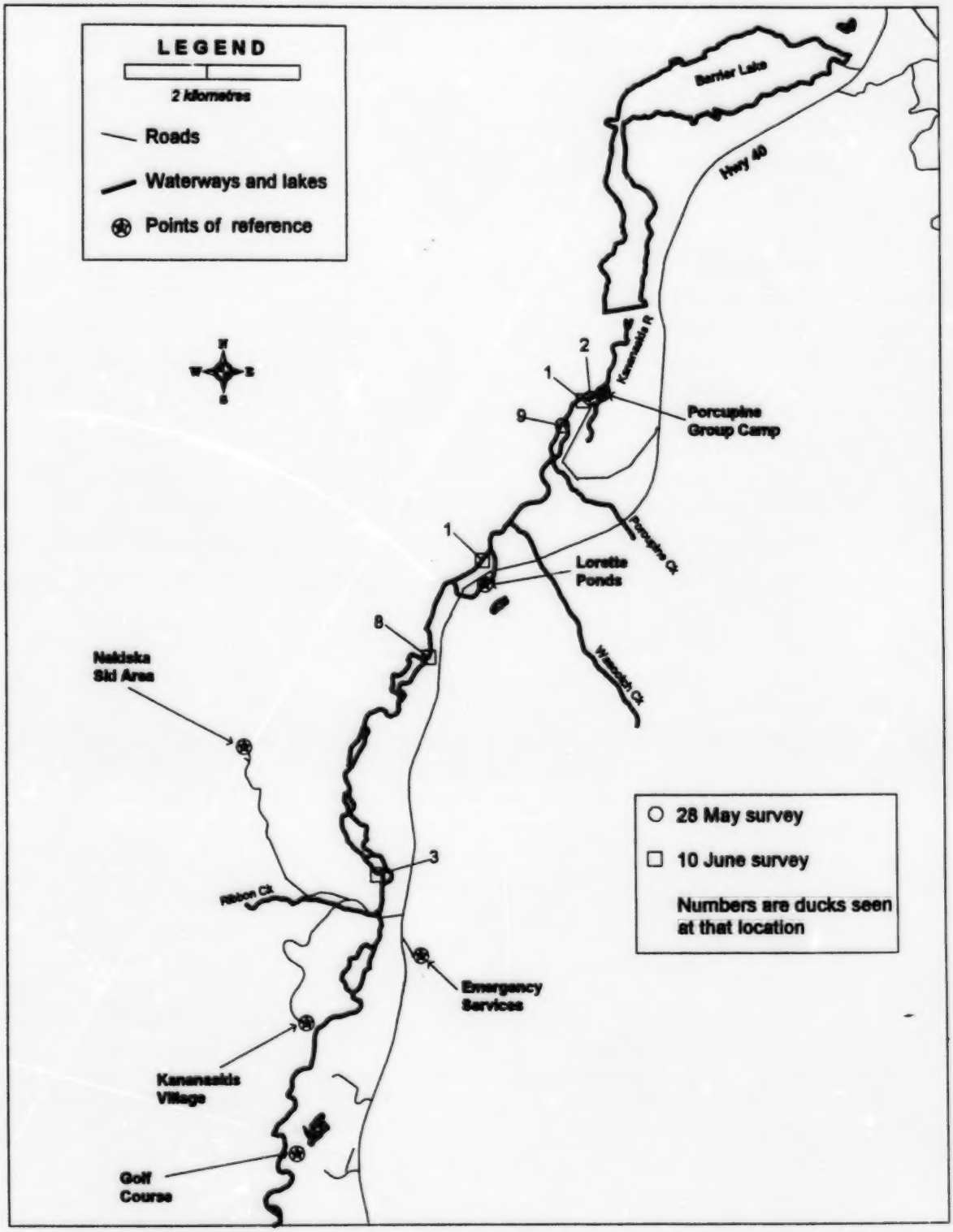

Figure 6. Locations of Harlequin Ducks observed on the Kananaskis River during roadside/hikin surveys on 28 May (n = 11) and 10 June (n = 13), 2000.

Table 6. Population estimates calculated from roadside surveys on the Kananaskis River, 2000.

Date	initial # of birds (N_1)	# known if banded	# banded (M_2)	Pop. (N)	Varianc (S^2)	S.D.	S.E.	95% C.I.
5-May	29	2	0	89.0	2610.0	51.1	5.4	100.1
13-May	35	6	5	41.0	30.0	5.5	0.9	10.8
19-May	35	9	3	89.0	864.0	29.4	3.1	57.6
28-May	35	11	5	71.0	308.6	17.6	2.1	34.4
10-Jun	35	9	4	71.0	372.0	19.3	2.3	37.8
Median				71.0	372.0	19.3	2.3	37.8

Table 7. Population estimates for adult harlequin ducks as calculated from roadside surveys (*n*) on the Kananaskis River, 1998-2000.

Year	n=	Pop. Est. (N)	Variance	S.D.	S.E.	95% C.I.
1998	3	41.0	68.4	8.3	1.3	16.2
1999	8	43.0	95.9	9.8	1.7	19.2
2000	5	71.0	372.0	19.3	2.3	37.8

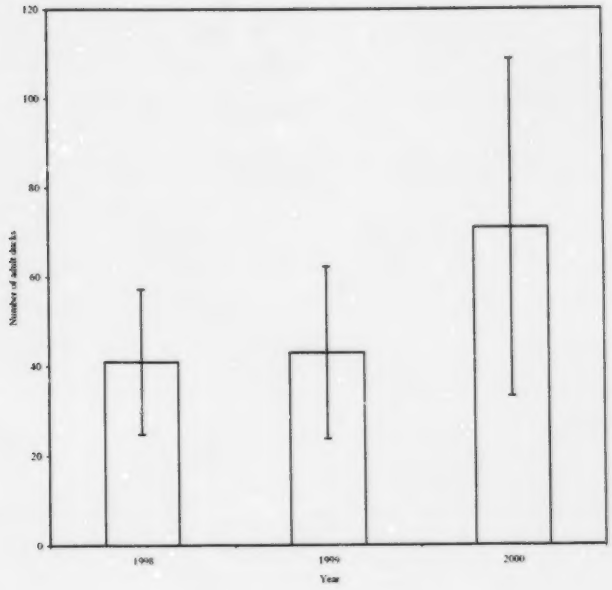

Figure 7. Population estimates for adult harlequin ducks on the Kananaskis River, 1998-2000.

4.3 Estimating Survival Rates

The data used for survival analysis on the Elbow River was filtered for the males and females that had received internal radio transmitters in 1997, due to concern over the effect of the radios on survival. The most conservative model for both populations suggested survival varied between males and females, but the recapture rate was the same. The estimated survival rate for males on the Elbow was 0.529 ± 0.123 S.E. (0.299-0.747 C.I.) and for females 0.592 ± 0.164 (0.278-0.846), with a recapture probability for both sexes of 0.844 ± 0.139 (0.406-0.977). The survival rate for males on the Kananaskis River was estimated at 0.719 ± 0.210 (0.249-0.952) and for females 0.852 ± 0.236 (0.129-0.996), with a recapture probability of 0.519 ± 0.194 (0.190-0.833).

The apparent lower survival rate for males than females may reflect the pairing behaviour of harlequin ducks rather than true survival. Some males that have only been sighted once may be alive but breeding in a different area. If a male's original mate dies, he will attempt to re-pair (Smith et al. 2000) and would follow his new mate to her natal stream, thus being counted as "dead" on his original stream.

4.4 Brood Surveys

Seven days were spent attempting to capture and band harlequin duck females and young in August 2000 (Table 8). Figure 8 shows the locations of the broods on the Kananaskis River at the time of first sighting or capture.

Table 8. Results of stream surveys for harlequin duck broods in Kananaskis Country, 2000.

Date	Stream	Distance (km)	Time (hrs)	Total	F	HY [a]	Comments
22-Aug	Kananaskis R.	4.5	4	6	1	5	banded brood
23-Aug	Kananaskis R.	2	1.5	7	3	4	banded hen with 4 HY; 2 females
24-Aug	Elbow R.	10.2	7	4	1	3	unable to capture brood
25-Aug	Highwood R.	7.5	4	0			
25-Aug	Cataract Ck.	4.8	3	0			
28-Aug	Kananaskis R.	7	6	6	1	5	HY banded; hen escaped net
30-Aug	Sheep R.	5.7	6	8	1	7	banded brood; one HY missed
31-Aug	Smith-Dorrien Ck.	6.5	5	0			

[a] HY – hatch year (ducklings)

4.5 Productivity

Only one of eight females (13%) observed on the Elbow River produced young ($n = 3$) in 2000, or 0.38 ducklings/female. This corresponds to a reproductive output (R_0) of 1.18 (Table 9). On the Kananaskis River four of 11 females (36%) produced ducklings ($n = 14$) in 2000, or 1.27 ducklings/female, for an R_0 of 3.96.

Table 9. Productivity of female harlequin ducks on the Elbow River (1996-2000) and Kananaskis River (1998-2000).

year	total females [a]	ducklings observed	ducklings/female	R_0 [d]
Elbow				
1996	5	10	2.00	6.24
1997	13	13	1.00	3.12
1998	7	5	0.71	2.20
1999	5	2	0.40	1.24
2000	8	3	0.38	1.18
Kananaskis				
1998	8	10	1.25	3.90
1999	12	19	1.58	4.93
2000	11	14	1.27	3.96

[a] based on surveys and number of banded females in that year
[b] during August usually
[c] including successful, failed and non-breeding females
[d] net reproductive rate = (ducklings/female x 0.78) x 4 (see methods)

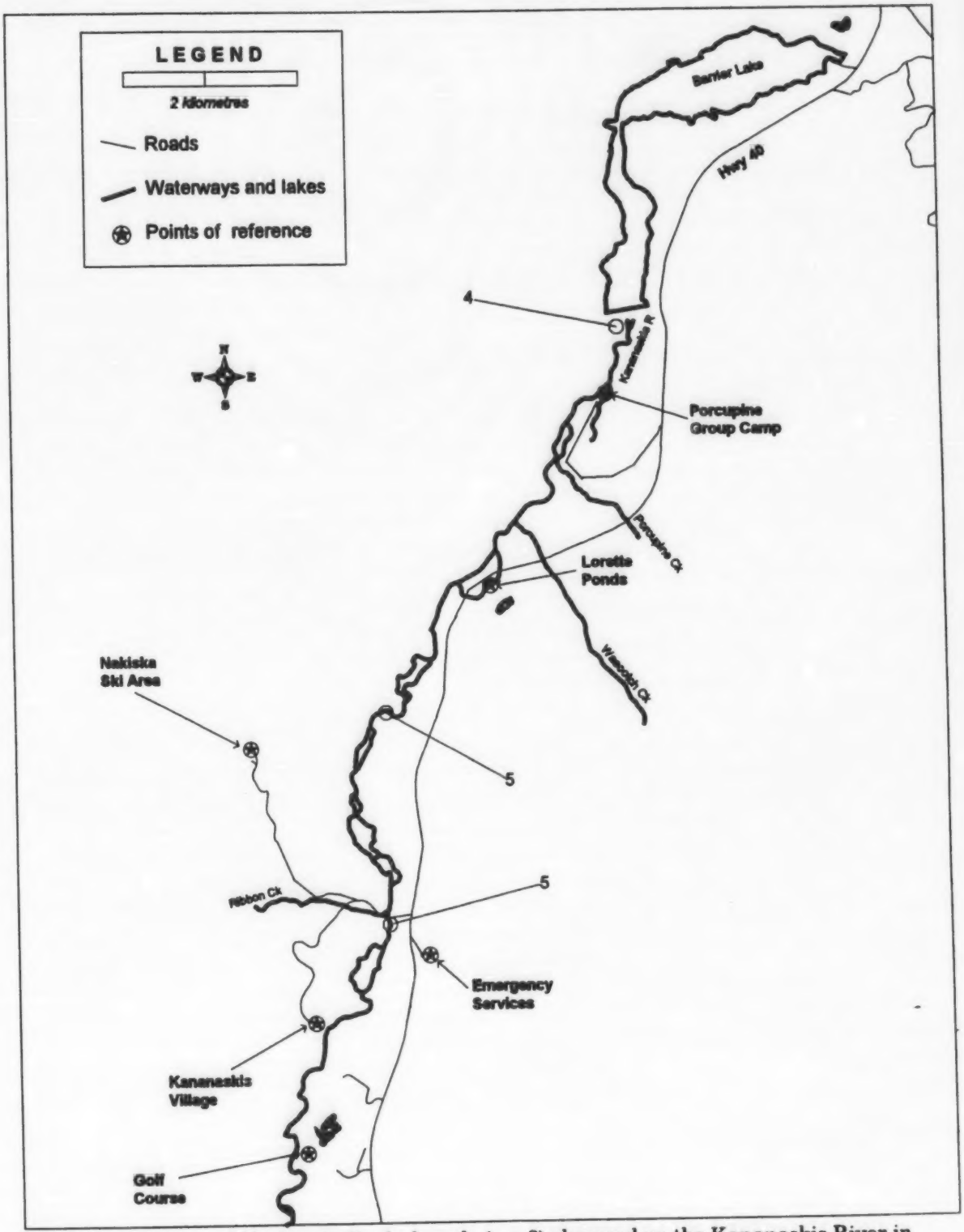

Figure 8. Locations of Harlequin Ducks broods (n = 3) observed on the Kananaskis River in 2000 (numbers refer to ducklings in each brood).

4.6 Regional and Coastal Resightings

On May 19, 2000 female AY (yellow band with lime green letters) was observed on the Kananaskis River near Lorette Ponds. An unbanded male accompanied her. This female had been banded June 1999 on the Macleod River south of Hinton, Alberta (MacCallum and Godsalve 2000), and was observed two weeks later on the Kananaskis River near Ribbon Creek (Smith 2000a). This is the first record of such a long dispersal during the breeding season — approximately 270 km to the southeast of where she was banded, across five major watersheds. Interestingly, she returned to the Kananaskis River rather than the Macleod River in 2000. She was observed with an unbanded male, but whether she nested was unknown.

There have been two even greater dispersals of young females from KC. In May 2000 female XN was observed with male XS (aqua) on Upper McDonald Creek in Glacier National Park, Montana (J. Hardin, pers. comm.). XN was banded as a duckling August 1998 on Smith-Dorrien Creek. XS had been banded August 1998 near Campbell River, British Columbia.

On May 15, 2000, female XY was observed on the Athabasca River near Jasper, Alberta (W. Hughson, pers. comm.). On May 17 she was observed with male 1E (white). XY had been banded as a duckling August 1998 on the Kananaskis River. 1E was banded August 1995 at Skidegate Inlet, Queen Charlotte Islands, British Columbia. Female XP had been observed on March 18 at the wintering area at Denman Island, British Columbia. Figure 9 shows the movements of these three females. These are the first recorded observations of young females dispersing from their natal area during the breeding season.

5.0 DISCUSSION

5.1 Population Analysis

Individually marked harlequin ducks on both the Elbow and Kananaskis rivers allowed for the determination of population estimates for both areas. The population estimate of 42 (± 11 S.D.) adults for the Elbow was higher than previous estimates of 1997 (27 ± 4), 1998 (23 ± 4) or 1999 (27.5 ± 8). While not significantly different than previous years, the trend is increasing. On the Kananaskis River the population estimate for 2000 was 71 (± 19), compared to 41 (± 8) birds in 1998 and 43 (± 10) in 1999. The estimate for 2000 is significantly higher than in 1999, with a resulting increasing trend. These increases could reflect higher numbers of young females returning to breed (i.e., result of high productivity 3-5 years previously) and/or increased adult survival. With a long-lived species such as the harlequin duck it is possible that adult population numbers can stay high even though productivity is dropping.

5.2 Productivity

Only one of eight females (13%) observed on the Elbow River produced young ($n = 3$) in 2000. This was lower than in 1997 (23%), 1998 (28%), or 1999 (20%). On the Kananaskis River four of 11 females (36%) produced ducklings ($n = 14$) in 2000. In 1999, five of 12 females (42%) produced ducklings ($n = 19$), and in 1998 three of eight females (37%) produced 10 ducklings. The estimated R_0 for the Elbow River has declined from 6.24 to 1.18

between 1996 and 2000, while the estimated R_0 for the Kananaskis River has remained similar at 3.90, 4.93 and 3.96 for 1998-2000 respectively.

It is uncertain what effect increasing recreational boating use of the Elbow River is having on Harlequin Duck productivity. If the reproductive output continues to be less than 2.0 then the population could eventually decline.

Other studies found the reproductive output on the Bow River in Banff National Park (1996-1999), varied from 0.62 to 2.34, with the last three years of the study all being below 2.0 (Smith 2000b). On the McLeod River in west central Alberta, R_0 has declined from a high of 6.12 in 1996 to 1.75 in 1999 (adapted from MacCallum and Godsalve 2000).

5.3 Survival Estimates

This project estimated survival rates for the first time after the 2000 field season. The sample sizes were smaller on the Elbow River (11 males, six females) than on the Kananaskis River (13 males, eight females). Male survival is likely biased low since a male may still be alive but have followed a new mate to a different breeding stream. There was no difference in survival estimates for the same sex between the two rivers. These estimates should be interpreted cautiously because of small sample sizes, which are evident in the wide confidence intervals. Studies done on the Bow River in Banff National Park calculated survival estimates (1995-1999) were 0.71 ± 0.14 S.E. (0.48-0.87 C.I.) for females, and for males was 0.81 ± 0.13 (0.44-0.96) (Smith 2000b).

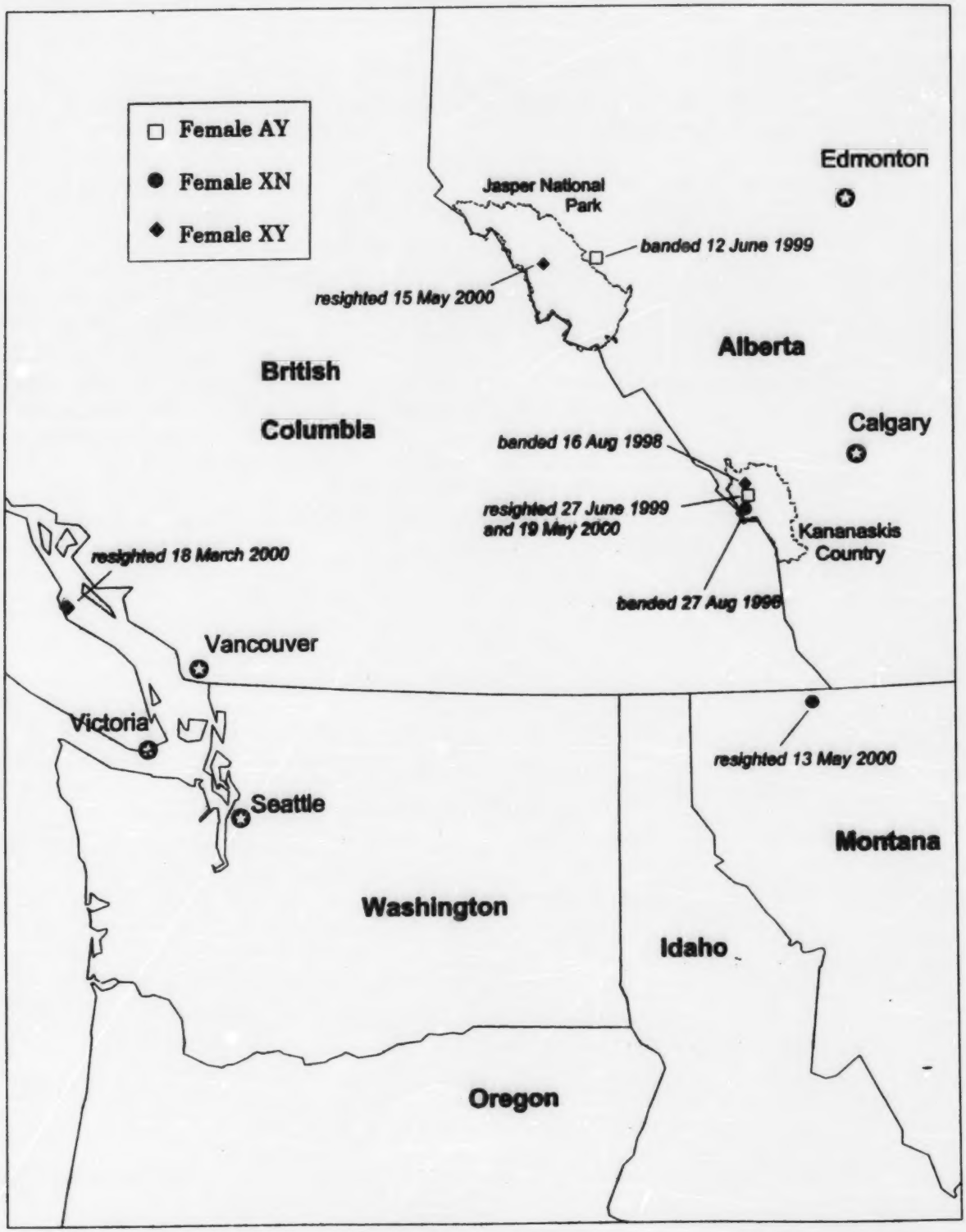

Figure 9. Movements of three females banded or observed in Kananaskis Country, that were also observed elsewhere in 2000.

6.0 RECOMMENDATIONS

1. Survey streams prior to increasing levels of human use: Any stream with suitable habitat that is proposed for physical or chemical alteration, or increased human use, should be surveyed for level of use and productivity by harlequin ducks.

2. Continue monitoring Elbow River: Monitoring harlequin duck productivity on the Elbow River should continue in order to determine if the decline in reproductive output is a true decline or a dip in long-term variability.

3. Investigate correlation between boating and low productivity on the Elbow River: The level of recreational boating on the Elbow River, and its impact on harlequin duck productivity, continues to be an unknown factor.

4. Prevent further development or activities along sections of the Kananaskis River: The reach of the Kananaskis River between the Kananaskis Golf Course and Barrier Lake continues to support a large number of harlequin ducks, and has high productivity. Some nesting occurs directly on the banks of the river, as well as away from the river on smaller tributaries. No further development or activities (e.g., facility or trail improvements, new shoreline access, commercial lodges, or expansion of existing commercial development) should be allowed along this section of the river.

5. Survey Cataract Creek to determine breeding importance: Although only a small part of the Cataract Creek watershed was surveyed, the number of breeding pairs suggests that it may be an important breeding stream in the southern part of the region.

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APPENDIX 1. Observations of harlequin ducks in Kananaskis Country and Straight of Georgia, BC, in 2000

DATE	TOT	F	M	PR	YOY	LOCATION	CODE	NOTES	SUR
14-Mar-00	1	1				Hornby Island, BC	YJ-or	f-YJ-orange	
14-Mar-00	2	1	1			Hornby Island, BC	SU, ST	m-SU with f-ST	
14-Mar-00	1	1				Hornby Island, BC	6C-aq	f-6C-aq	
14-Mar-00	1		1			Hornby Island, BC	XP	m-XP	
18-Mar-00	1	1				Hornby Island, BC	LA	f-LA	
18-Mar-00	1	1				Denman Island, BC	XY	f-XY	
18-Mar-00	1		1			Hornby Island, BC	NT	m-NT in SY plumage	
18-Mar-00	1		1			Hornby Island, BC	NP	m-NP in SY plumage	
18-Mar-00	1		1			Hornby Island, BC	VZ	m-VZ	
18-Mar-00	1		1			Hornby Island, BC	63	m-63	
18-Mar-00	1		1			Hornby Island, BC	NS-aq	m-NS-aq	
18-Mar-00	2	1	1			Denman Island, BC	VO, XR	m-VO, seen with f-XR	
18-Mar-00	1		1			Hornby Island, BC	B7-aq	m-B7-aq	
18-Mar-00	1	1				Hornby Island, BC	BA-aq	f-BA-aq	
20-Mar-00	1		1			Hornby Island, BC	NC	m-NC in SY plumage	
20-Mar-00	1	1				Hornby Island, BC	LP	f-LP	
22-Mar-00	1		1			Hornby Island, BC	KA-wh	m-KA-wh	
22-Mar-00	1	1				Hornby Island, BC	NA	f-NA	
24-Mar-00	1		1			Hornby Island, BC	78	m-78	
24-Mar-00	1		1			Toby Island, BC	91-gr	m-91-g	
24-Mar-00	1	1				Hornby Island, BC	LC	f-LC	
26-Mar-00	1		1			Hornby Island, BC	LB	m-LB in SY plumage	
26-Mar-00	1		1			Hornby Island, BC	NJ	m-NJ	
26-Mar-00	1	1				Hornby Island, BC	SL-wh	f-SL-wh	
05-May-00	4		4			Lorette Ponds		2-unb, 2-unk; flew upstream	Rd
05-May-00	1		1			Mt Allen viewpoint corner		unk; feeding in pools	Rd
09-May-00	4	1	3			Kananaskis R u/s of Ribbon Ck	LI, VJ, NS-aq/r, LJ	band m-LI, m-LJ; recap f-VJ, m-NS-aq/r	Bd
10-May-00	1	1				Elbow R. u/s of Paddy's Flats	ST	recap f-ST	Bd
11-May-00	3	1	2	1		Elbow R u/s of Elbow R. Launch	49, UP, US	band m-UP & f-US; recap m-49	Bd
11-May-00	4	2	2	2		Elbow R. u/s of Paddy's Flats	LZ, LU, 37, LR	band f-LZ, m-LU, m-LR; recap f-37	Bd
12-May-00	2	1	1	1		Kananaskis R at Nakiska Br	UI, UV	band f-UI & m-UV	Bd
12-May-00	2	1	1	1		Prarie Creek junction	ST, SU	f-ST with nd RWS/LBLT & m-SU	Rd

Appendix 1 continued

App. 1, con't.

DATE	TOT	F	M	PR	YOY	LOCATION	CODE	NOTES	SUR
12-May-00	7	3	4	3		Elbow Falls	FH-g/l, KA-w/r, LF-g/l, US, UP	f-FH-g/r with nd RGR/LRR, m-LF-g/l with nd LOC/RWR, f-US & m-UP	Rd
12-May-00	2	1	1	1		Paddy's Flats	H8, EF-g/l	f-H8 & m-EF-g/l	Rd
13-May-00	6	2	4	2		Lorette Ponds Corner	LA, YJ-or/r, NS-g/r, EE, LJ	f-LA & m-LJ, f-YJ-orange/r & m-NS-aq/r, m-EE, m-unb	Rd
16-May-00	2	1	1	1		Sheep Falls picnic area		unb	Rd
17-May-00	2	1	1	1		Highwood R d/s of Stony Ck	73	f-73 & m-unb	Rd
19-May-00	2	1	1	1		upstream of Porcupine camp		unb pr	Rd
19-May-00	2	1	1	1		Wasootch Creek		f-red/left unknown & m-unk	Rd
19-May-00	2	1	1	1		Lorette Ponds	AY-y/r	f-AY-y/r & m-unb	Rd
19-May-00	6	1	5	1		Mount Allen viewpoint corner		f-r/l unk & m-unb, m-unb, m-unb, pr unk	Rd
20-May-00	6	3	3	3		Elbow Falls Picnic	US, UP, KA-w/r	pr unb, f-US & m-UP, f-unb & m-KA-w/r	Rd
20-May-00	2	1	1	1		below Elbow Falls	LF-g/r	m-LF-g/r with nd LOC/RWR	Rd
21-May-00	2	1	1	1		Cataract Ck jct with Wilkinson		unb; f feeding, m guarding	Rd
21-May-00	2	1	1	1		Cataract campground	VU	f-VU & m-unb	Rd
21-May-00	4	2	2	2		Catarct Creek		2 pr unb	Rd
21-May-00	2	1	1	1		Highwood R u/s of Stony Ck		pr unk	Rd
22-May-00	2	1	1	1		Sheep R above Falls		unb; feeding	Rd
22-May-00	1		1			Sheep R at Indian Oils		unknown; floated downstream	Rd
24-May-00	4	1	3			Sheep R d/s of Junction Ck	UJ, UG, UO, UA	band m-UJ, m-UG, m-UA, f-UO	Bd
26-May-00	3	1	2			Cataract Ck	UK, UU, UF	band m-UK, m-UU, f-UF	Bd
26-May-00	2	1	1	1		Paddy's Flats-Silvester Creek	UI, UV	f-UI & m-UV	Rd
26-May-00	2	1	1	1		Prarie Creek junction	ST, SU	f-ST with nd LBLT/RWC & m-SU	Rd
26-May-00	1		1			below Elbow Falls	LF-g/r	m-LF-g/r with nd LOC/RWR	Rd
26-May-00	2	1	1	1		Beaver Pond Trail		unb	Rd
26-May-00	2	1	1	1		Beaver Flats Campground	FH-g/r	f-FH-g/r with nd LRR/RGR & m-unb	Rd
26-May-00	4	2	2	2		Ford Creek junction		2 pr unb	Rd
28-May-00	2	1	1	1		upstream of Porcupine camp	VT, VN	f-VT & m-VN	Rd
28-May-00	9	4	4	4		upstream of Porcupine camp	89, 81, XB	2 pr unb, f-89 & m-81, f-XB & m-unb, m-unb	Rd
10-Jun-00	1		1			Porcupine Group camp	VH	m-VH, flew away	Rd
10-Jun-00	1		1			Lorette Ponds		unk; flying upstream	Rd
10-Jun-00	8	2	6	2		Mount Allen viewpoint corner	LJ	2 pr unb, m-LJ, 2 m-r/l unk, m-unk	Rd
10-Jun-00	3	2	1	1		Nakiska Bridge		unk; swimming downstream together	Rd
11-Jun-00	1		1			Paddy's Flats	LU	m-LU	Rd
11-Jun-00	2	1	1	1		upstream of Prarie Creek Jct.		pr unb, hiding	Rd
11-Jun-00	1		1			Beaver Flats viewpoint	UP	m-UP	Rd

Appendix 1 continued

App. 1, con't.

DATE	TOT	F	M	PR	YOY	LOCATION	CODE	NOTES	SUR
22-Aug-00	6	1			5	Kananaskis R at Sundance L.	XR, UN, UX, UY, UL, UB	recap f-XR; band Hys UN, UX, UY, UL, UB	Bd
23-Aug-00	7	3			4	Kananaskis R at Barrier Lake	UZ, 32, ZU, UR, UC, UH, UE	band fem-UZ and Hys UR, UC, UH, UE; recap f-32, band f-ZU	Bd
25-Aug-00	4	1			3	Elbow R at Paddy's Flats		unbanded; tried to capture but unsuccessful	Bd
28-Aug-00	5				5	Kananaskis R at Ribbon Ck	ZS, ZJ, ZT, ZH, ZZ	band Hys ZS, ZJ, ZT, ZH, ZZ; fem escaped	Bd
30-Aug-00	7	1			6	Sheep R at Gorge Ck	ZG, ZN, ZX, ZE, ZF, ZY, ZK	band f-ZN with Hys ZG, ZX, ZE, ZF, ZY, ZK	Bd
05-Sep-00	7	1			6	Lower Kananaskis L at Kent Ck			R

TOT – Total PR – Pairs SUR – Survey type; R (random), Bd (banding), Rd (roadside), T (telemetry) Kan – Kananaskis
Ck – creek unk – unknown if banded unb - unbanded

APPENDIX 2. Banding and resighting record of marked harlequin ducks in Kananaskis Country, 1996-2000.

Code	Age	Sex	Date banded	96	Pr	HY	97	Pr	HY	98	Pr	HY	99	Pr	HY	00	Pr	HY	Where banded	Notes
12	HY	M	22-Aug-97				1			0						0			Highwood	prog of SL
13	HY	F	22-Aug-97				1			0						0			Highwood	prog of SL
14	HY	M	22-Aug-97				1			0						0			Sheep	prog of 61
16	HY	F	23-Aug-97				1			0						0			Elbow	prog of 53
17	HY	M	22-Aug-97				1,1*			0						0			Highwood	prog of SL
18	HY	M	22-Aug-97				1			0						0			Sheep	prog of 61
21	HY	M	8-Aug-97				1			0						0			Elbow	prog of 31
22	ASY	M	14-Jun-96	1	N		0			0						0			Elbow	
23	ASY	M	15-Jun-96	1	24		0			0			1*,0			0			Elbow	
24	ATY	F	15-Jun-96	1	23	7	0			0						0			Elbow	one HY not captured
25	TY	F	18-Jul-96	1	N		1	unb	6	0						0			Elbow	radio/97; predated/97
26	ATY	F	27-Jul-96	1	unk	5	0			0						0			Sheep	
27	HY	unk	27-Jul-96	1			-			0						0			Sheep	prog of 26
28	HY	F	8-Aug-96	1			-			0						0			Elbow	prog of 24; on Bow R. 10-May-99
29	HY	M	8-Aug-96	1			-			0						0			Elbow	prog of 38
31	ATY	F	8-Aug-97				1	unk	4	0						0			Elbow	band changed to ZV in 2000
32	HY	F	2-Aug-96	1			-			0						0			Kananaskis	prog of 32
33	HY	M	2-Aug-96	1			-			0						0			Kananaskis	prog of 32
34	HY	F	2-Aug-96	1			-			0						0			Kananaskis	prog of 32
35	TY	F	4-Aug-96	1			1*			1,1*	SR			SR		0			Kananaskis	radio/98; nested, predated
36	HY	F	8-Aug-96	1			-			1	86					1	LR		Elbow	prog of 38
37	ATY	F	8-Aug-96	1	unk	4	1	39	0	0						0			Elbow	radio/97; nest predated
38	ASY	M	10-May-97				1	38		0						0			Elbow	radio/97
39	HY	F	7-Aug-97				1			0						0			Kananaskis	died after radio implant/97
41	HY	unk	7-Aug-96	1			-			0						0			Elbow	prog of 24; disappeared/dead?
42	HY	M	7-Aug-96	1			-			1*,0						0			Elbow	prog of 24
43	HY	F	7-Aug-96	1			-			0						0			Elbow	prog of 24
44	HY	F	7-Aug-96	1			-			1	N					0			Elbow	prog of 24
45																				

Appendix 2 continued

App. 2, con't.

Code	Age	Sex	Date banded	96	Pr	HY	97	Pr	HY	98	Pr	HY	99	Pr	HY	00	Pr	HY	Where banded	Notes
46	HY	F	7-Aug-96	1			-			1	N		1*,0			0			Elbow	prog of 24; on Elbow in 1998
47	HY	F	8-Aug-96	1			-			0						0			Elbow	prog of 38
48	HY	F	8-Aug-96	1			-			0			1	Y	2	0			Elbow	prog of 38
49	ASY	M	10-May-97				1,1*			1*, 1			1*,0			1			Elbow	radio/97
51	HY	M	22-Aug-97				1			0						0			Sheep	prog of 61
53	ATY	F	10-May-97				1	54	3	1	54	1		54		0			Elbow	
54	ASY	M	10-May-97				1	53		1	53			53		0			Elbow	radio/97; also on Kan. R
55	HY	F	22-Aug-97				1			0						0			Sheep	prog of 61
56	ASY	M	10-May-97				1	59		0						0			Elbow	
57	HY	F	22-Aug-97				1			0						0			Highwood	prog of SL
59	ATY	F	10-May-97				1	56		0						0			Elbow	radio/97; non-breeder
61	ATY	F	22-Aug-97				1	unk	6	0						0			Sheep	
62	HY	M	15-Aug-96	1,1*			-			1*						0			Highwood	prog of 65 or 72
63	HY	M	15-Aug-96	1			1*			1*			1*,0	1*,0		0			Highwood	prog of 65 or 72
64	HY	M	15-Aug-96	1			1*			1*			1*,0			0			Highwood	prog of 65 or 72
65	ATY	F	15-Aug-96	1	unk	1-7?	1*			0						0			Highwood	with 72 & 8 HY
66	HY	F	15-Aug-96	1			-			0						0			Highwood	prog of 65 or 72
67	HY	F	15-Aug-96	1			-			0						0			Highwood	prog of 65 or 72
68	HY	M	15-Aug-96	1			1*			1*,0						0			Highwood	prog of 65 or 72
69	HY	M	15-Aug-96	1			-			0						0			Highwood	prog of 65 or 72
72	ATY	F	15-Aug-96	1	unk	1-7?	0			0						0			Highwood	with 65 & 8 HY
73	ATY	F	30-Jul-97				1	unk	3	1*,0			1*,1	unb		1	unb		Highwood	
74	HY	F	8-Aug-97				1			0						0			Elbow	prog of 31
76	HY	M	30-Jul-97				1			0						0			Highwood	prog of 73
77	HY	M	30-Jul-97				1			1*,0			1*,0			0			Highwood	prog of 73
78	HY	M	30-Jul-97				1			1*,0			1*,0	1*,0		0			Highwood	prog of 73
79	HY	F	8-Aug-97				1			0						0			Elbow	prog of 31
81	ASY	M	14-Jun-97				1	89		1	89			81		1	89		Kananaskis	
82	ASY	M	10-May-97				1	87		1	87					0			Elbow	
84	ASY	M	14-Jun-97				1			1*,0						0			Kananaskis	
85	ASY	M	14-Jun-97				1			0						0			Kananaskis	
86	ASY	M	10-May-97				1	unb		1	37					0			Elbow	had injured right leg/97

Appendix 2 continued

App. 2, con't.

Code	Age	Sex	Date banded	96	Pr	HY	97	Pr	HY	98	Pr	HY	99	Pr	HY	00	Pr	HY	Where banded	Notes
87	ATY	F	10-May-97				1	82		1	82					0			Elbow	
88	ASY	M	14-Jun-97				1			0				N		0			Kananaskis	also seen on Elbow
89	ATY	F	14-Jun-97				1	81		1	81			81		1	81		Kananaskis	
93	ASY	M	16-Jun-97				1			0			1*,0			0			Sheep	
94	ASY	M	16-Jun-97				1,1*	98		0,1*			1*,0			0			Sheep	
95	HY	F	23-Aug-97				1			0						0			Elbow	prog of 53; predated on river
96	HY	F	23-Aug-97				1			0						0			Elbow	prog of 53
97	HY	M	22-Aug-97				1			0						0			Sheep	prog of 61
98	ATY	F	16-Jun-97				1,1*	94		0,1*						0			Sheep	
99	HY	M	22-Aug-97				1			0						0			Sheep	prog of 61
AU	ASY	M	7-May-98							1,1*	OV			N		0			Kananaskis	was 75 g/r; mate predated/98
GF	ATY	F	2-Sep-98							1	Y	2				0			Kananaskis	one HY not captured; radio/98
GU	HY	F	2-Sep-98							1			-			0			Kananaskis	prog of GF; radio/98
LA	ATY	F	25-Aug-99										1		3	1*,1	LJ		Kananaskis	
LB	HY	M	25-Aug-99										1			1*,-			Kananaskis	prog of LA
LC	HY	F	25-Aug-99										1			1*,-			Kananaskis	prog of LA
LG	HY	F	25-Aug-99										1			-			Kananaskis	prog of LA
LI	ASY	M	9-May-00													1			Kananaskis	
LJ	ASY	M	9-May-00													1	LA		Kananaskis	
LK	HY	F	25-Aug-99										1			-			Kananaskis	prog of XC
LP	HY	F	25-Aug-99										1			1*,-			Kananaskis	prog of XC
LR	ASY	M	11-May-00													1	37		Elbow	
LS	HY	M	25-Aug-99										1			-			Kananaskis	prog of XC
LU	HY	F	26-Aug-99										1			-			Elbow	prog of 48
LU	ASY	M	11-May-00													1	LZ		Elbow	
LX	HY	M?	26-Aug-99										1			-			Elbow	prog of 48
LZ	AHY	F	11-May-00													1	LU		Elbow	
NA	ATY	F	29-Jun-99													1*,0			Kananaskis	
NB	HY	M	20-Aug-99													-			Kananaskis	prog of NV
NC	HY	M	20-Aug-99													1*,-			Kananaskis	prog of 6C
NG	HY	F	20-Aug-99													-			Kananaskis	prog of NV

Appendix 2 continued

App. 2, con't.

Code	Age	Sex	Date banded	96	Pr	HY	97	Pr	HY	98	Pr	HY	99	Pr	HY	00	Pr	HY	Where banded	Notes
NK	HY	M	20-Aug-99													-			Kananaskis	prog of 32
NJ	HY	M	20-Aug-99													1*,-			Kananaskis	prog of NV
NP	HY	M	20-Aug-99													1*,-			Kananaskis	prog of NV
NR	HY	F	20-Aug-99													-			Kananaskis	prog of 32
NT	HY	M	20-Aug-99													1*,-			Kananaskis	prog of 32
NU	HY	F	20-Aug-99													-			Kananaskis	prog of 32
NV	ATY	F	20-Aug-99											Y	5	0			Kananaskis	
NY	HY	M	20-Aug-99													-			Kananaskis	prog of 32
NZ	HY	F	20-Aug-99													-			Kananaskis	prog of NV
SB	ATY	F	7-May-98							1,1*	SS		1			0			Kananaskis	radio/98
SE	ATY	F	11-May-98							1	SZ	4		SZ		0			Elbow	
SF	HY	M	16-Aug-98							1,1*			-			0			Kananaskis	prog of XR; radio/98
SG	ASY	M	7-May-98							1	N		1*,0			0			Kananaskis	
SI	HY	M	16-Aug-98							1,1*			-			0			Kananaskis	prog of XR; radio/98
SO	ASY	M	10-May-98							1	SP			SP		0			Kananaskis	
SP	ATY	F	10-May-98							1,1*	SO			SO		0			Kananaskis	radio/98
SR	ASY	M	8-May-98							1	36			36		0			Kananaskis	
SS	ASY	M	7-May-98							1,1*	SB		1*,0			0			Kananaskis	
ST	ATY	F	11-May-98							1,1*	SU	N	1*,1	SU		1*,1	SU		Elbow	
SU	ASY	M	11-May-98							1	ST		1*,1	ST		1*,1	ST		Elbow	
SV	ASY	M	8-May-98							1	BA		0			0			Kananaskis	
SX	ASY	M	7-May-98							1			0			0			Kananaskis	
SY	ASY	M	8-May-98							1	N		0			0			Kananaskis	
SZ	ASY	M	11-May-98							1	SE			SE		0			Elbow	
UA	ASY	M	24-May-00													1			Sheep	
UB	HY	M	22-Aug-00													1			Kananaskis	prog of XR
UC	HY	F	23-Aug-00													1			Kananaskis	prog of UZ
UE	HY	M	23-Aug-00													1			Kananaskis	prog of UZ
UF	TY	F	26-May-00													1	UU		Cataract Ck	
UG	ASY	M	24-May-00													1			Sheep	
UH	HY	F	23-Aug-00													1			Kananaskis	prog of UZ
UI	TY	F	12-May-00													1	UV		Kananaskis	
UJ	ASY	M	24-May-00													1			Sheep	

Appendix 2 continued

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Code	Age	Sex	Date banded	96	Pr	HY	97	Pr	HY	98	Pr	HY	99	Pr	HY	00	Pr	HY	Where banded	Notes
UK	ASY	M	26-May-00													1	red		Cataract Ck	
UL	HY	M	22-Aug-00													1			Kananaskis	prog of XR
UN	HY	M	22-Aug-00													1			Kananaskis	prog of XR
UO	SY?	F	24-May-00													1			Sheep	
UP	ASY	M	11-May-00													1	US		Elbow	
UR	HY	M	23-Aug-00													1			Kananaskis	prog of UZ
US	ATY	F	11-May-00													1	UP		Elbow	
UU	ASY	M	26-May-00													1	UF		Cataract Ck	
UV	ASY	M	12-May-00													1	UI		Kananaskis	
UX	HY	F	22-Aug-00													1			Kananaskis	prog of XR
UY	HY	M	22-Aug-00													1			Kananaskis	prog of XR
UZ	TY	F	23-Aug-00													1	unk	4	Kananaskis	
VA	HY	M	30-Aug-98							1			-			-			Smith-Dorrien Ck	prog of VC; radio/98; predated
VB	HY	M	30-Aug-98							1			1*			-			Smith-Dorrien Ck	prog of VC; radio/98; predated
VC	ATY	F	30-Aug-98							1,1*	Y	4	0			0			Smith-Dorrien Ck	radio/98
VG	ATY	F	26-May-99											VX		0			Elbow	
VH	ASY	M	15-Aug-99											?		1			Kananaskis	
VI	ATY	F	30-May-99										1	VN		0			Cataract Ck	
VJ	HY	F	30-Aug-98							1			-			1			Smith-Dorrien Ck	prog of VC; radio/98
VK	ATY	F	26-May-99											N		0			Elbow	with another female
VL	ASY	M	15-Aug-99											Y		0			Kananaskis	
VN	ASY	M	30-May-99										1	VI		1	VT		Cataract Ck	
VO	ASY	M	16-Aug-99											XR		1*,0			Kananaskis	
VR	HY	F	10-Sep-98							1			-			-			Smith-Dorrien Ck	prog of VC; radio/98; predated
VS	ATY	F	16-May-99											VY		0			Kananaskis	
VT	ATY	F	15-May-99											B7		1	VN		Kananaskis	radio/99
VU	ATY	F	30-May-99										1	VZ		1	unb		Cataract Ck	
VX	ASY	M	26-May-99											VG		0			Elbow	
VY	ASY	M	16-May-99											VS		0			Kananaskis	
VZ	ASY	M														1*,0			Cataract Ck	replaces XR-g/r
XA	HY	F	16-Aug-98							1,1*			-			0			Kananaskis	prog of XR; radio/98

Appendix 2 continued

App. 2, con't.

Code	Age	Sex	Date banded	96	Pr	HY	97	Pr	HY	98	Pr	HY	99	Pr	HY	00	Pr	HY	Where banded	Notes
XB	HY	F	16-Aug-98							1,1*			-			1			Kananaskis	prog of XE
XC	ATY	F	15-Aug-99											XZ	5	0			Kananaskis	
XE	ATY	F	16-Aug-98							1	Y	2	1*,-			0			Kananaskis	radio/98
XF	ASY	M												?		0			Kananaskis	replaces BJ-g/r
XG	HY	M	27-Aug-98							1			-			0			Smith-Dorrien Ck	prog of XL
XJ	ATY	F	15-May-99											Y		0			Kananaskis	
XK	ATY	F	15-May-99										1*,1	Y		0			Kananaskis	radio/99
XL	ATY	F	27-Aug-98							1,1*	Y	4	0			0			Smith-Dorrien Ck	radio/98
XN	HY	F	27-Aug-98							1,1*			-			1			Smith-Dorrien Ck	prog of XL; Montana in 2000
XP	HY	M	16-Aug-98							1,1*			1*,-			1*,0			Kananaskis	prog of XR; radio/98
XR	ATY	F	16-Aug-98							1	Y	6	1*,1	VO		1*,1	?	5	Kananaskis	
XT	HY	M	16-Aug-98							1			1*,-			0			Kananaskis	prog of XR; radio/98
XU	HY	F	16-Aug-98							1,1*			-			0			Kananaskis	prog of XE
XV	HY	M	27-Aug-98							1,1*			-			0			Smith-Dorrien Ck	prog of XL
XX	HY	F	27-Aug-98							1,1*			-			0			Smith-Dorrien Ck	prog of XL
XY	HY	F	16-Aug-98							1,1*			-			1*,1			Kananaskis	prog of XR; radio/98; JNP/00
XZ	ASY	M	15-Aug-99											XC		0			Kananaskis	
ZE	HY	F	30-Aug-00													1			Sheep	prog of ZN
ZF	HY	M	30-Aug-00													1			Sheep	prog of ZN
ZG	HY	M	30-Aug-00													1			Sheep	prog of ZN
ZH	HY	M	28-Aug-00													1			Kananaskis	hen not captured
ZJ	HY	M	28-Aug-00													1			Kananaskis	hen not captured
ZK	HY	M	30-Aug-00													1			Sheep	prog of ZN
ZN	ATY	F	30-Aug-00													1	?	7	Sheep	
ZS	HY	F	28-Aug-00													1			Kananaskis	hen not captured
ZT	HY	F	28-Aug-00													1			Kananaskis	hen not captured
ZU	SY	F	23-Aug-00													1			Kananaskis	
ZV	ATY	F	2-Aug-96	1	unk	6	0			1				Y	4	1			Kananaskis	band changed to ZV in 2000
ZX	HY	M	30-Aug-00													1			Sheep	prog of ZN
ZY	HY	F	30-Aug-00													1			Sheep	prog of ZN
ZZ	HY	F	28-Aug-00													1			Kananaskis	hen not captured

Appendix 2 continued

App. 2, con't.

Code	Age	Sex	Date banded	96	Pr	HY	97	Pr	HY	98	Pr	HY	99	Pr	HY	00	Pr	HY	Where sighted	Notes
3F-g/r	ASY	M	1-Aug-94	1	N		1	unb		0,1*			0			0			Elbow	
3N-r/r	ASY	M	27-May-97				1	N		1	unb		1*,1			0			Kananaskis	banded on Macleod R./97
6C-aq	ATY	F	15-Aug-98											Y	4	1*,0			Kananaskis	2 HY escaped net
9I-g/r	ASY	M	19-Aug-95	1	unb		0			0			0			1*,0			Elbow	
B7-aq	ASY	M	15-Aug-98											Y		1*,0			Kananaskis	
J5-w/r	SY	F	23-Aug-95				1*,1	unk		0			0			0			Highwood	maybe nested up Cataract Ck
N2-w/r	ATY	F	22-Aug-95	1	unk	3	0			0			0			0			Kananaskis	
AY-yl/r	AHY	F	12-Jun-99										1	N		1	unb		Kananaskis	banded on Macleod R
BA-aq/r	ATY	F	20-Aug-97							1,1*	SV	N	0			1*,0			Kananaskis	radio/98
BJ-g/r	ASY	M	30-Jul-94										0			0			Kananaskis	replaced with XF
EE-r/l	ASY	M	10-May-96	1*			1	AH		1	N		0			1	N		Kananaskis	banded on Bow; mate on Bow
EF-g/l	ASY	M	31-Jul-94													1	H8-r/l?		Elbow	
FH-g/r	ATY	F	5-Aug-94													1	unb		Elbow	
KA-w/r	ASY	M	24-Aug-95													1*,1	unb		Elbow	
LF-g/r	ASY	M	10-Aug-94													1	unb		Elbow	
NS-aq/r	ASY	M	20-Aug-98													1*,1	YJ-o/r		Kananaskis	
OV-w/r	ATY	F	20-Aug-95							1	AU	N	0			0			Kananaskis	radio/98; predated/98
P0-g/r	ASY	M	3-Aug-94	1	unb		0,1*			0			0			0			Elbow	
SL-w/r	ATY	F	19-Sep-95	1*			1*,1	unk	4	0,1*			0			1*,0			Highwood	
VJ-o/r	ATY	F	17-Sep-99													1*,1	NS-aq/r		Kananaskis	
XJ-y/l	ASY	M	unknown							1			0	N		0			Kananaskis	
XR-g/r	ASY	M	5-Aug-94										1	Y		0			Cataract Ck	replaced with VZ

Code: red/left unless noted, g (green), r (red), w (white), aq (aquamarine), y (yellow), lg (lime green), /r (band on right leg)
Age at banding: HY (hatch year – duckling), SY (second year), TY (third year), ASY (after second year), ATY – after third year
Pr = pair status: blank is unknown if paired, N (not paired), code (paired, mate's code), unb (paired, unbanded), unk (paired but unknown if mate banded)
Under **year**: 1 (seen on breeding stream), 0 (not seen on breeding stream, 1* (seen at coast)
Unk: unknown as to sex, or banded or not unb: unbanded prog: progeny